Credit Chain and Price Variations
- Very Preliminary and Do Not Cite - *

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Abstract

In this paper, I build up a model with multiple pricing behaviors in a sequence of financial transactions. Prices can be more volatile with multiple pricings since such a long transaction chain tends to include a variety of disturbances. I evaluate how separation rates, matching efficiencies in frictional financial markets, entry costs into markets, and bargaining powers among banks hold significant effects on pricings through simulations. I apply this model to Japanese and US mortgage backed securities data and estimate a model by using the Bayesian method. In Japan and US, price variations of mortgage backed securities are bigger than those of returns of safe assets. This tendency is clearer in the US market. Our model provides several policy/regulation designs to reduce such excessive price variations by changing bargaining powers among financial institutions and matching elasticities in financial markets. By variance decompositions, I show that such appropriate policies for a price stability change by the types of shocks to financial markets.

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1 Introduction

In this paper, I build up a model with multiple price settings in a line of financial transactions by a theory of search and matching.[1] Here, in each financial transaction, price settings by other agents in other financial transactions hold effects on own price setting and vise versa. Eventually, shocks in other markets have effects on own price setting. Moreover, a bargaining power between a seller and a buyer changes a price setting behavior. In a model, a seller and a buyer need to search for a counterpart in each financial transaction. There exists a search friction in a financial transaction and this friction amplifies price variation. Moreover, once one part of a line of financial transactions would be disrupted, a whole transaction stops all contracts in the line and financial agents need to make a new line of financial transactions.

Our model is applicable to analyze prices in residential mortgage backed securities and asset backed securities. For example, in residential mortgage backed securities, traditional/commercial banks first provide mortgage loans to households. Here, we have a first negotiation to set a price, i.e., interest rate on housing loan. Then, banks securitize these loans and sell these residential mortgage backed securities to investment banks. In this process, we have a second negotiation to set a price, i.e., return on residential mortgage backed securities. Furthermore, in some cases, investment banks wrap up residential mortgage backed securities as one final financial product and sell it to investors. Here, we have a third negotiation to set a price, i.e., return on a final financial product. In these financial transaction, we observe financial transaction chain through a sequential price setting as replicated in our model.

I first implement normative analyses to show model's properties. In particular, I change separation rates in financial transactions, bargaining powers for interest rate settings among banks, entry costs into financial markets, and matching elasticity. Price variations sensitively change by these parameters and types of shocks. This implies that we have several ways to design a policy to stabilize price variations.

Through analysis using a model, I reveal roles of financial regulations on financial

[1] Mortensen and Pissarides (1994) develop a search model for a labor market.

system in particular on financial transactions with long transaction chain such as mortgage backed securities and asset backed securities. I discuss how we avoid large price variations under financial crisis and evaluate what kind of policy tools are effective to stabilize price variations. In particular, I focus on policies working on bargaining powers among banks in setting prices, matching elasticity in frictional market, entry costs into financial markets, and separation rate in financial contracts. Under monopolistic markets, monopolistic financial institution has a large bargaining power and distorts pricings. For example, monopolistic financial institution tend to set misleadingly high prices (low yields) to investors as shown in the last sub-prime mortgage crisis. Thus, such policies are necessary to stabilize prices. Moreover, if one of financial institutions can play a role of a regulator as Japan Housing Finance Agency in Japan, policies working on such as bargaining powers among banks are realistic and reasonable. I show that price variations in financial markets can decreases to different types of shocks by giving appropriate regulations.

Then, I apply the model to Japanese and US mortgage backed security data and estimate a financial chain model using Bayesian methods. In particular, I use mortgage backed securities data issued by Japan Housing Finance Agency for Japan. Japan Housing Finance Agency buys long-term fixed-rate housing loans, so called as Flat 35, from the private financial institutions and issues mortgage backed securities that are backed by these trust assets. The outstanding amount of mortgage backed securities issued by Japan Housing Finance Agency has increased steadily and reached to about 14 trillion yen at FY2019 as shown in Japan Housing Finance Agency (2020). On the other hand, many financial institutions, including main three institutions of Fannie Mae, Freddie Mac, and Ginnie Mae, issue mortgage backed securities in US and a market size is much larger than in Japan. The outstanding amount of mortgage backed securities has increased to 11,671 billion dollars at the second quarter of 2021.[2]

Using data, I show that prices of mortgage backed securities are more volatile than those of safer assets in Japan and US. Estimation results uncover parameters such as

[2]Source: SIFMA and Bloomberg.

bargaining powers among financial institutions for price setting in a financial chain, matching elasticities in financial markets, and entry costs into financial markets. By variance decomposition, I also reveal what types of shocks are dominant to make price variations. One reason why I use Japanese and US data is different market maturities and sizes for mortgage backed securities. In US, a market for mortgage backed securities is much larger than Japan and there was a financial crisis induced by mortgage backed securities. Another reason is that government-related agencies participate in mortgage backed security markets in these countries and it is realistic and feasible to consider policies for these markets through such agencies. Then, by using a model, I show several ways to reduce price variations for mortgage backed securities.

Our model is related to a model with a search friction. In particular, Wong and Wright (2014) show a role of chains of intermediaries, so called middlemen, on price determinations in a search model. Nosal et al. (2019) make a model where economic agents behave as producers or intermediaries in a search model. They show that financial intermediation induces multiple equilibria and unstable belief-based dynamics, implying that a financial intermediation contributes to make a financial market unstable. Gautier et al. (2021) show an important role of middleman in a financial market. They make a model where a middleman mode and a market-making mode are endogenously determined. Awaya et al. (2021) make a rational bubble model where a chain of middlemen sequentially trade assets.

The rest of our paper is organized as follows. Section 2 describes our model. I show a log-linear model in Section 3. Section 4 provides normative analysis using a model under a variety of parameters and shocks. Section 5 provides positive analysis after estimating a financial chain model using Bayesian estimation methods for Japanese. Section 6 shows a case for US economy. Section 7 shows how we design policy/regulation in Japan and US for a price stability.

2 Financial Chain Model

2.1 Model Setting

There are two financial markets, a first market between banks A and banks B and a second market between banks B and banks C. Structures of two markets are as follows in a time sequence. First, dissolved banks in the last period search for matches for financial transactions in the first market and match with a certain probability. Second, newly matched bank B in the first market can search for matches for financial transactions in the second market. Only when a match is successful for banks B in the second market, banks B can make financial transactions in two markets. Third, a first market opens and banks A and banks B newly matched in the market set an interest rate. When firm B sets an interest rate in the first market, bank B knows the result of interest rate setting in the second market as in Wasmer and Weil (2004) that assume two sequential bargaining in a loan market and a labor market. Forth, a second market opens and banks B and banks C newly matched in the market set an interest rate. When banks set an interest rate in the second market, an interest rate in a first market is as given since a negotiation for an interest rate finished in the first market before the second market opens. Fifth, banks A and banks B are dissolved with a separation rate $\rho \in (0,1)$. When a bank B is dissolved in the first market, a match between the bank B and the bank C is also dissolved since an interruption of a credit chain. Sixth, banks B and banks C are dissolved with a separation rate $\dot{\rho} \in (0,1)$. When a bank B is dissolved in the second market, a match between the bank A and the bank B is also dissolved similarly as in the first market.

In two markets, transitions of banks' matching are given by

$$N_t = (1-\rho)(1-\dot{\rho})N_{t-1} + \dot{q}_t \dot{v}_t, \tag{1}$$

$$v_t = N^* - (1-\rho)(1-\dot{\rho})N_{t-1}, \tag{2}$$

$$\dot{v}_t = q_t v_t, \tag{3}$$

where N_t is number of matched banks in two markets, q_t and $\dot{q}_t$ are probability of filling vacancies in the first market and second market respectively, and v_t and $\dot{v}_t$ are number of vacancies in the first market and second market respectively. Note that equation (1) holds for two market.

In the second market between banks B and banks C, bank C can be either an active bank or a seeker bank, where a number of seeker is given by $\dot{u}_t$. An active bank lend $Z^C R_t^C$, where Z^C is demand for lending and R_t^C is shock on demand. Thus, this term works as demand for financial products. To be active, a bank must borrow Z^B from banks B. A second financial market is characterized by search frictions, and the flow cost of searching for a vacancy is $\dot{\kappa} > 0$ paid by banks C. With probability $\dot{s}_t$, a seeker bank C is matched with a bank B. Bank C then receives Z^B, lend R_t^C to the next bank in a credit chain, and pay back $R_t^B Z^B$ to bank B, where R_t^B is an interest rate newly set in a second market at time t. We assume that R_t^C is a random interest rate for simplicity.

There is free entry into a second financial market. In equilibrium, the value of a seeker bank C is zero, and hence the cost of searching must equal the expected revenue, or

$$\dot{\kappa} = \dot{s}_t \dot{Q}_t(R_t^B). \tag{4}$$

Here, $\dot{Q}_t(R_t^B)$ is the value of an active bank C as

$$\dot{Q}_t(R_t^B) = Z^C R_t^C - Z^B R_t^B + \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t \dot{Q}_{t+1}(\widetilde{R}_{t+1}^B). \tag{5}$$

The first two terms on the RHS of equation (5) show the net current profit from lending, while the third term is the discounted present value of future profit.

Banks B join in two markets. First, banks B join in the first market as in former sections. There is free entry into a first market. In equilibrium, the value of a seeker bank B is zero, and hence the cost of searching must equal the expected revenue, or

$$\kappa = s_t \dot{q}_t Q_t(R_t^A, R_t^B), \tag{6}$$

where where s_t is probability of match by a search in the first market and R_t^A is a newly set price in the first market for loans A at time t. A value function of banks B in the market is given as

$$Q_t(R_t^A, R_t^B) = Z^B R_t^B - Z^A R_t^A + \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t Q_{t+1}(\widetilde{R}_{t+1}^A, \widetilde{R}_{t+1}^B). \tag{7}$$

When banks B set an interest rate of R_t^A, bank B guesses interest rate setting for R_t^B. Banks B need to borrow Z_A from banks to join in the market.

After interest rate setting in the first market, banks B join in a second market given R_t^A and set R_t^B. Banks B must post offers, which we call "vacancies" in the second market, to search for seeker of bank C. Posting vacancies is costless. The value of a new match for a bank B is

$$\dot{J}_t^1(R_t^A, R_t^B) = Z^B R_t^B - Z^A R_t^A - X_t^B + \beta \mathrm{E}_t \left\{ (1-\rho)(1-\dot{\rho}) \dot{J}_{t+1}^1(\widetilde{R}_{t+1}^A, \widetilde{R}_{t+1}^B) + [1-(1-\rho)(1-\dot{\rho})] \, \dot{J}_{t+1}^0 \right\}, \tag{8}$$

where X_t^B is an exogenous cost shock for financial transactions. Note that this equation holds given R_t^A since bank B join in a second market only after banks B match banks A with R_t^A. Moreover, once banks B is dissolved with banks C, these banks B exit from two markets.

On the other hand, the value of a vacancy for a bank B is

$$\dot{J}_t^0 = \beta \mathrm{E}_t \left[\dot{q}_{t+1} \dot{J}_{t+1}^1(\widetilde{R}_{t+1}^A, \widetilde{R}_{t+1}^B) + (1-\dot{q}_{t+1}) \dot{J}_{t+1}^0 \right]. \tag{9}$$

Since a vacancy yields no current profit, it has only discounted future values. These two equations imply that the surplus of a bank B from a new match is

$$\begin{aligned} \dot{J}_t^1(R_t^A, R_t^B) - \dot{J}_t^0 &= Z^B R_t^B - Z^A R_t^A - X_t^B \\ &\quad + \beta \mathrm{E}_t \left\{ [(1-\rho)(1-\dot{\rho}) - \dot{q}_{t+1}] \left[\dot{J}_{t+1}^1(\widetilde{R}_{t+1}^A, \widetilde{R}_{t+1}^B) - \dot{J}_{t+1}^0 \right] \right\}, \end{aligned} \tag{10}$$

In the first market, the value of a new match for a bank A is

$$J_t^1(R_t^A) = Z^A R_t^A - X_t^A + \beta \mathrm{E}_t \left\{ (1-\rho)(1-\dot{\rho}) J_{t+1}^1(\widetilde{R}_{t+1}^A) + [1-(1-\rho)(1-\dot{\rho})] \, J_{t+1}^0 \right\}, \tag{11}$$

where X_t^A is an exogenous cost for financial transaction. The first term on the RHS shows current profit from lending, while the second term represents the discounted present value of a future profit.

On the other hand, the value of a vacancy for a bank A is

$$J_t^0 = \beta \mathrm{E}_t \left[q_{t+1} \dot{q}_{t+1} J_{t+1}^1(\widetilde{R}_{t+1}^A) + (1 - q_{t+1}\dot{q}_{t+1}) J_{t+1}^0 \right]. \tag{12}$$

Since a vacancy yields no current profit, it has only discounted future values. These two equations imply that the surplus of a bank A from a new match is

$$J_t^1(R_t^A) - J_t^0 = Z^A R_t^A - X_t^A + \beta \mathrm{E}_t \left\{ \left[(1-\rho)(1-\dot{\rho}) - q_{t+1}\dot{q}_{t+1}\right] \left[J_{t+1}^1(\widetilde{R}_{t+1}^A) - J_{t+1}^0 \right] \right\}. \tag{13}$$

The number of new matches in a period is given by a Cobb-Douglas matching functions in two markets

$$m\left(u_t, v_t\right) = \chi u_t^{1-\alpha} v_t^{\alpha}, \ \chi \in \left(0, 1\right), \ \alpha \in \left(0, 1\right), \tag{14}$$

$$m\left(\dot{u}_t, \dot{v}_t\right) = \dot{\chi} \dot{u}_t^{1-\dot{\alpha}} \dot{v}_t^{\dot{\alpha}}, \ \dot{\chi} \in \left(0, 1\right), \ \dot{\alpha} \in \left(0, 1\right), \tag{15}$$

where χ, $\dot{\chi}$, α, and $\dot{\alpha}$ are parameters.

Defining supply and demand in a first and second markets, respectively, as

$$\theta_t = \frac{u_t}{v_t}, \tag{16}$$

$$s_t = \chi \theta_t^{-\alpha}, \tag{17}$$

$$q_t = \chi \theta_t^{1-\alpha}, \tag{18}$$

$$\dot{\theta}_t = \frac{\dot{u}_t}{\dot{v}_t}, \tag{19}$$

$$\dot{s}_t = \dot{\chi} \dot{\theta}_t^{-\dot{\alpha}}, \tag{20}$$

$$\dot{q}_t = \dot{\chi} \dot{\theta}_t^{1-\dot{\alpha}}. \tag{21}$$

The interest rates are determined according to Nash bargainings between the newly matched firms. A new interest rate R_t^A is set by only newly matched firms. Thus, R_t^A solves

$$\max_{R_t^A} \left[Q_t(R_t^A, R_t^B) \right]^{1-b} \left[J_t^1(R_t^A) - J_t^0 \right]^b, \tag{22}$$

where $b \in (0, 1)$ is the bargaining power for bank A. The first-order condition with respect to R_t^A yields

$$b Q_t(R_t^A, R_t^B) = \tau(1-b) \left[J_t^1(R_t^A) - J_t^0 \right], \tag{23}$$

where $\tau \equiv b$. Note that τ is given by an assumption that bank B knows the result of interest rate setting in the second market when bank B set an interest rate in the first market.

For a new interest rate R_t^B, we have

$$\max_{R_t^B} \left[\dot{Q}_t(R_t^B)\right]^{1-\dot{b}} \left[\dot{J}_t^1(R_t^A, R_t^B) - \dot{J}_t^0\right]^{\dot{b}}, \tag{24}$$

where $\dot{b} \in (0,1)$ is the bargaining power for bank B in the second market. The first-order condition with respect to R_t^B yields

$$\dot{b}\dot{Q}_t(R_t^B) = (1-\dot{b}) \left[\dot{J}_t^1(R_t^A, R_t^B) - \dot{J}_t^0\right]. \tag{25}$$

In a model, except shocks, we have 17 endogenous variables, N_t, u_t, $\dot{u}_t$, v_t, $\dot{v}_t$, θ_t, $\dot{\theta}_t$, s_t, $\dot{s}_t$, q_t, $\dot{q}_t$, R_t^A, R_t^B, Q_t, $\dot{Q}_t$, $J_t^1(R_t^A) - J_t^0$, and $\dot{J}_t^1(R_t^A, R_t^B) - \dot{J}_t^0$, and 17 equations for endogenous variables, equations (1), (2), (3), (4), (5), (6), (7), (10), (13), (16), (17), (18), (19), (20), (21), (23), and (25).

2.2 Closed Economy

For simulations, we show a small set of equations that includes the same number of endogenous variables. There are two equations for a credit chain. An equation for interest rate in a second financial market is given by equations (4), (10), (19), (20), (21), and (25) as

$$R_t^B = \frac{\beta\dot{\kappa}\dot{b}}{Z^B}\dot{\theta}_{t+1} + \frac{(1-\dot{b})Z^A}{Z^B}R_t^A + \frac{1-\dot{b}}{Z^B}X_t^B + \frac{\dot{b}Z^C}{Z^B}R_t^C. \tag{26}$$

An equation for interest rate in a first financial market is given by equations (6), (7), (13), (16), (17), (18), and (23) for the first market as

$$R_t^A = \frac{\beta\kappa b}{\left[b + b(1-b)\right]Z^A}\theta_{t+1} + \frac{bZ^B}{\left[b + b(1-b)\right]Z^A}R_t^B + \frac{b(1-b)}{\left[b + b(1-b)\right]Z^A}X_t^A. \tag{27}$$

To more closely look at interaction effects between markets, we can combine equations (26) and (27) as

$$\begin{aligned} R_t^A = &\frac{\beta\kappa}{Z^A}\frac{1}{1-b+\dot{b}}\theta_{t+1} + \frac{\beta\dot{\kappa}}{Z^A}\frac{\dot{b}}{1-b+\dot{b}}\dot{\theta}_{t+1} \\ &+ \frac{1}{Z^A}\frac{1-b}{1-b+\dot{b}}X_t^A + \frac{1}{Z^A}\frac{1-\dot{b}}{1-b+\dot{b}}X_t^B + \frac{Z^C}{Z^A}\frac{\dot{b}}{1-b+\dot{b}}R_t^C, \end{aligned} \tag{28}$$

$$R_t^B = \frac{\beta\kappa}{Z^B}\frac{1-\dot{b}}{1-b+\dot{b}}\theta_{t+1} + \frac{\beta\dot{\kappa}}{Z^B}\frac{\dot{b}(2-b)}{1-b+\dot{b}}\dot{\theta}_{t+1} \\ + \frac{1}{Z^B}\frac{(1-b)(1-\dot{b})}{1-b+\dot{b}}X_t^A + \frac{1}{Z^B}\frac{(2-b)(1-\dot{b})}{1-b+\dot{b}}X_t^B + \frac{Z^C}{Z^B}\frac{\dot{b}(2-b)}{1-b+\dot{b}}R_t^C. \tag{29}$$

Market interactions give new features for price dynamics. First, a market tightness in one market makes a disturbance to an interest rate in another market. A response of an interest rate to own and another market tightness strengthens and weakens according to bargaining powers of b and $\dot{b}$ in two markets. Second, a shock in another market also plays an important role to dynamics since a shock in another market is included in equation. A response of an interest rate to a shock in own and another market can increase and decrease according to bargaining powers of b and $\dot{b}$.

From equations (4), (5), and (20), we have

$$\frac{\dot{\kappa}}{\dot{\chi}\dot{\theta}_t^{-\dot{\alpha}}} = Z^C R_t^C - Z^B R_t^B + \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t\frac{\dot{\kappa}}{\dot{\chi}\dot{\theta}_{t+1}^{-\dot{\alpha}}}. \tag{30}$$

From equations (6), (7), (17), and (21), we have

$$\frac{\kappa}{\chi\theta_t^{-\alpha}\dot{\chi}\dot{\theta}_t^{1-\dot{\alpha}}} = Z^B R_t^B - Z^A R_t^A + \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t\frac{\kappa}{\chi\theta_{t+1}^{-\alpha}\dot{\chi}\dot{\theta}_{t+1}^{1-\dot{\alpha}}}. \tag{31}$$

These two equations define the dynamics of θ_t and $\dot{\theta}_t$.

Then, from equations (26), (27), (30), and (31), we have a closed system for R_t^A, R_t^B, θ_t, and $\dot{\theta}_t$.

We assume following exogenous shocks.

$$X_t^A = \xi_{XA}X_{t-1}^A + \epsilon_t^{XA}, \tag{32}$$

$$X_t^B = \xi_{XB}X_{t-1}^B + \epsilon_t^{XB}, \tag{33}$$

$$R_t^C = \xi_{ZC}R_{t-1}^C + \epsilon_t^{XC}, \tag{34}$$

where ξ_{XA}, ξ_{XB}, and ξ_{ZC} are auto-regressive parameters and ϵ_t^{XA}, ϵ_t^{XB}, and ϵ_t^{XC} are i.i.d shocks.

3 Log-linearization

We log-linearize the closed economy model around a steady state. Four log-linearized equations describing the closed economy are given as

$$\hat{R}_t^B = \frac{\beta\dot{\kappa}\bar{\dot{\theta}}\dot{b}}{M}\mathrm{E}_t\hat{\dot{\theta}}_{t+1} + \frac{Z^A\bar{R}^A(1-\dot{b})}{M}\hat{R}_t^A + \frac{\bar{X}^B(1-\dot{b})}{M}\hat{X}_t^B + \frac{Z^C\bar{R}^C\dot{b}}{M}\hat{R}_t^C, \tag{35}$$

$$\hat{R}_t^A = \frac{\beta\kappa\bar{\theta}}{N}\mathrm{E}_t\hat{\theta}_{t+1} + \frac{Z^B\bar{R}^B}{N}\hat{R}_t^B + \frac{\bar{X}^A(1-b)}{N}\hat{X}_t^A, \tag{36}$$

$$\hat{\dot{\theta}}_t = \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t\hat{\dot{\theta}}_{t+1} + \frac{Z^C\bar{R}^C}{H}\hat{R}_t^C - \frac{Z^B\bar{R}^B}{H}\hat{R}_t^B, \tag{37}$$

$$\hat{\theta}_t = \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t\hat{\theta}_{t+1} + \frac{1-\dot{\alpha}}{\alpha}\left[\hat{\dot{\theta}}_t - \beta(1-\rho)(1-\dot{\rho})\mathrm{E}_t\hat{\dot{\theta}}_{t+1}\right] + \frac{Z^B\bar{R}^B}{K}\hat{R}_t^B - \frac{Z^A\bar{R}^A}{K}\hat{R}_t^A, \tag{38}$$

where

$$M \equiv Z^B\bar{R}^B \equiv \beta\dot{\kappa}\bar{\dot{\theta}}\dot{b} + Z^A\bar{R}^A(1-\dot{b}) + \bar{X}^B(1-\dot{b}) + Z^C\bar{R}^C\dot{b}, \tag{39}$$

$$N \equiv Z^A\bar{R}^A\frac{b+b(1-b)}{b} \equiv \beta\kappa\bar{\theta} + Z^B\bar{R}^B + \bar{X}^A(1-b), \tag{40}$$

$$H \equiv \frac{\dot{\kappa}\dot{\alpha}\bar{\dot{\theta}}^{\dot{\alpha}}}{\dot{\chi}} \equiv \frac{\dot{\alpha}}{1-\beta(1-\rho)(1-\dot{\rho})}\left(Z^C\bar{R}^C - Z^B\bar{R}^B\right), \tag{41}$$

$$K \equiv \frac{\kappa\bar{\theta}^{\alpha}\bar{\dot{\theta}}^{\dot{\alpha}-1}}{\chi\dot{\chi}} \equiv \frac{1}{1-\beta(1-\rho)(1-\dot{\rho})}\left(Z^B\bar{R}^B - Z^A\bar{R}^A\right). \tag{42}$$

We also have log-linearized shocks.

$$\hat{X}_t^A = \rho_{XA}\hat{X}_{t-1}^A + \hat{\epsilon}_t^{XA}, \tag{43}$$

$$\hat{X}_t^B = \rho_{XB}\hat{X}_{t-1}^B + \hat{\epsilon}_t^{XB}, \tag{44}$$

$$\hat{R}_t^C = \rho_{ZC}\hat{R}_{t-1}^C + \hat{\epsilon}_t^{XC}, \tag{45}$$

where ρ_{XA}, ρ_{XB}, and ρ_{ZC} are auto-regressive parameters and $\hat{\epsilon}^{AC}$, $\hat{\epsilon}^{XB}$, and $\hat{\epsilon}^{XC}$ are i.i.d shocks.

4 Normative Analysis

In this section, I show effects of parameters and shocks on price settings using log-linearized model.[3] In particular, we focus on roles of a search friction by α and $\dot{\alpha}$, a bargaining power among agents by b and $\dot{b}$, and separation rate by ρ and $\dot{\rho}$. I also give three types of shocks, X_t^A, X_t^B, and R_t^C.

I set a baseline parameters as shown in Table 1. A discount rate is a conventional value in a monthly base as $\beta = 0.996$. I set matching efficiency as $\chi = \dot{\chi} = 0.5$ and entry cost into a market as $\kappa = \dot{\kappa} = 2$. For parameters of a search friction by α and $\dot{\alpha}$, a bargaining power among agents by b and $\dot{b}$, and separation rate by ρ and $\dot{\rho}$, I set these values as in Table 1 as a baseline case and I change these values and evaluate how parameters are effective on price settings. I set shock persistence as $\rho_{XA} = \rho_{XB} = \rho_{ZC} = 0.5$ as a base case.

4.1 Effect of Separation Rates on Prices

Table 2 shows simulation results when we change separation rates in two financial markets to three types of shocks.

For a shock in the first market X_t^A that works for banks A as an increase in a funding cost by a default risk, price variations increase as separation rates increase. This is because banks are less forward-looking and more focus on present shocks as separation rates increase as shown in equations (30) and (31).

A shock of X_t^B works for banks B as an increase in funding cost by a default risk in the second market. We see similar results as a case of a shock of X_t^A.

I also show a case of a shock of R_t^C. This shock works for all banks as an increase in a final demand for financial products. A market size increases when a shock of R_t^C increases. In this case, price variations decrease as separation rates increase. This is because $Z^C R_t^C$ and $Z^B R_t^B$ moves in the same direction for a shock of R_t^C and a variation

[3] To run simulations, we need a steady state for a model. When we change deep parameters, we re-calculate steady state values and reflect these values in simulations.

by $\dot{\theta}_{t+1}$ is more volatile than ones by $Z^C R_t^C - Z^B R_t^B$ in equation (30).

These results imply that different types of shocks give different implications for separation rates. Thus, we need to identify which a shock plays an important role in financial market to know desire separation rates to stabilize prices.

4.2 Effect of Bargaining Power on Prices

Table 3 shows simulation results when I change bargaining powers on price setting among banks to three types of shocks.

For a shock of X_t^A in the first market, simulation results show that price variations decrease when b and $\dot{b}$ decrease in each market. This implies that larger bargaining powers in supply sides in two markets can decrease price variations to a shock of X_t^A.

For a shock of X_t^B, price variations basically decrease when b decrease in a first market and price variations decrease when $\dot{b}$ increases in a second market. It means that bargaining powers on banks B need to be larger to reduce price variations to a shock of X_t^B since the shock occurs in a second market.

For a shock of R_t^C, simulation result show interesting pattern. Price variations increase in two market when $\dot{b}$ increases in a second market regardless of increase or decrease in b. This is because a shock occurs in a second market.

These results again imply that we need to identify which a shock plays an important role in financial market to know desire separation rates to stabilize prices.

4.3 Effect of Matching Elasticity on Prices

Table 4 shows simulation results when I change matching elasticity on price setting among banks to three types of shocks. For three types of shocks, simulation results are very complex and con not find specific patters in these results. Combinations of matching elasticities sensitively change price variations.

To reduce price variations in two markets, we need to put larger elasticity on demand side in a first market and smaller elasticity on demand side in a second market such as $\alpha = 0.3$ and $\dot{\alpha} = 0.7$ to a shock of X_t^A. This means that price variations decrease when a matching elasticity of banks B should be larger. For a shock of X_t^A, we need an opposite parameter combination to reduce price variations in two markets. When $\alpha = 0.7$ and $\dot{\alpha} = 0.3$ and a matching elasticity of banks B is smaller, price variations decrease. For a shock of R_t^C, price variations decrease When $\alpha = 0.7$ and $\dot{\alpha} = 0.7$ and a matching elasticity of supply side in two market increase.

Thus, according to types of shocks, necessary responses are different to stabilize prices. We need to uncover roles of different types of shocks on price variations.

4.4 Effect of Entry Cost on Prices

Table 5 shows simulation results when we change entry cost κ and $\dot{\kappa}$ to enter into financial markets. Simulation results show that price variations decrease when κ and $\dot{\kappa}$ decrease in each market to a shock of X_t^A. This implies that smaller entry cost in two markets can decrease price variations to a shock of X_t^A. Moreover, smaller $\dot{\kappa}$ rather than smaller κ plays more important role to reduce price variations. We observe the same results for a shock of X_t^B.

For a shock of R_t^C, simulation results are opposite to cases of X_t^A and X_t^B. Price variations decrease when κ and $\dot{\kappa}$ increase in each market. This implies that larger entry cost in two markets can decrease price variations to a shock of R_t^C. Moreover, larger κ rather than larger $\dot{\kappa}$ plays more important role to reduce price variations.

According to types of shocks, necessary responses are different to stabilize prices.

5 Application to Japanese Mortgage Backed Securities Data

I apply our model to Japanese financial data. In particular, I use mortgage backed securities data issued by Japan Housing Finance Agency. In Japan, Japan Housing Finance Agency is the biggest provider for mortgage backed securities. Japan Housing Finance Agency buys long-term fixed-rate housing loans, so called as Flat 35, from the private financial institutions partnered with Japan Housing Finance Agency. Japan

Housing Finance Agency issues bonds that are backed by these trust assets.[4] Japan Housing Finance Agency starts to issue mortgage backed securities from 2007 in almost every month and we use these data.[5] The outstanding amount of mortgage backed securities issued by Japan Housing Finance Agency has increased steadily and reached to about 14 trillion yen at FY2019 as shown in Japan Housing Finance Agency (2020). Compared to Japanese gross domestic product, its ratio is about three percent.

Figure 1 shows 10-years Japanese government bond (JGB), a coupon price, and an weighted average coupon (WAC). WAC is issued by Japan Housing Finance Agency for each originated security and is an weighted average of return of securities that constitute a mortgage backed security by the amount outstanding. A coupon price is for newly issued mortgage backed security. We observe that a coupon price and WAC decreases with 10-years JGB. Spread between a coupon price/WAC and 10-years JGB is not so volatile regardless of two financial crises, in 2008 in the US and in 2012 in the Euro. Table 6 shows basic statistics for Figure 1. A standard deviation of a coupon price is 17 percent larger than that of return of a safe asset. Thus, a market environment to organize securities for mortgage backed securities is stable in Japan for a long time.

Our model is the most applicable to analyze coupon prices of mortgage backed securities by Japan Housing Finance Agency. Japan Housing Finance Agency set coupon price to investors when it issues mortgage backed securities. Here, there is a price negotiation between Japan Housing Finance Agency and these investors through a financial market conditions. In our model in Section 2, a coupon price of mortgage backed security is an interest rate between banks B and banks C in the second market, i.e., R_t^B. Here, banks B are Japan Housing Finance Agency and banks C is investors for mortgage backed securities. WAC can approximate an interest rate between banks A and banks B in the first market, i.e., R_t^A. Here, banks A, for example mega city banks and regional banks in Japan, provide mortgage loans to households and sell these original loans to

[4] Please see Japan Housing Finance Agency (2020) for transaction details between Japan Housing Finance Agency and partner private financial institutions.

[5] Former Government Housing Loan Corporation issued mortgage backed securities since March, 2001.

banks B as securities. This mortgage loan rates that corresponds to X_t^A in a model are approximated by 10-years JGB.

5.1 Bayesian Estimation for Japanese Mortgage Backed Securities

In this section, we estimate a financial chain model using Bayesian estimation method. In estimating the model, I use a log-linearized model as shown in Section 3.

5.1.1 Japanese Data

In estimation, I use monthly data series, over the sample period from June 2007 to December 2021, including a coupon price, average WAC, and 10-years JGB.

5.1.2 Calibrations and Priors for Estimation

I first calibrate some of the deep parameters. A discount rate is a conventional value in a monthly base as $\beta = 0.996$.[6] We set separation rates in two market as $\rho = 0.03$ and $\dot{\rho} = 0.03$ since a replacement of market participants are very slow in Japan. We set scaling parameters for a steady state such as $Z^A = 1$, $Z^B = 2$, and $Z^C = 8$.

The prior distributions for the estimated parameters is summarized in Table 7. For a financial market and a financial chain model, we have no previous studies for prior distributions. We assume Beta distribution for parameters that have restrictions $[0, 1]$ such as b, $\dot{b}$, α, $\dot{\alpha}$, ρ_{XA}, ρ_{XB}, and ρ_{XC}. For inverse Gamma distribution for standard deviations for shocks such as σ_{XA}, σ_{XB}, and σ_{XC}. We assume normal distributions for other parameters.

5.1.3 Estimation Results

Table 8 report estimated posterior means and the 5th and 95th percentiles.

[6] It implies $\beta = 0.99$ at a quarterly base.

Regarding bargaining power in two markets, a bargaining power of banks A in the first market is $b = 0.4764$ and a bargaining power of banks B in the second market is $\dot{b} = 0.4812$. Thus, bargaining powers are slightly stronger in buyer sides in two markets and there is no extreme bias in bargaining powers. For matching elasticity, we have $\alpha = 0.5545$ and $\dot{\alpha} = 0.6756$. Matching elasticities are relatively larger in supply sides.

As an evidence of market heterogeneity in Japan, parameters capturing market structures differ between two markets. Entry cost into a first market $\kappa = 1.6665$ is smaller than that in a second market $\dot{\kappa} = 2.2376$. Matching efficiency in a first market $\chi = 0.5997$ is larger than that in a second market $\dot{\chi} = 0.3143$. These results imply that participating a first market is easier thanks to lower entry cost and more chance to match in the market.

6 Application to US Mortgage Backed Securities Data

I apply our model to US financial data. In US, many financial institutions issue mortgage backed securities unlike Japan and a market size is much larger in US than in Japan. The outstanding amount of mortgage backed securities has increased to 11,671 billion dollars at the second quarter of 2021.[7]

Figure 2 shows an average of weighted average coupon (WAC), an average of newly issued coupon that is given by an weighted average of coupon price each month by the amount of outstanding, and return of a safe asset. Table 9 shows basic statistics for Figure 2. A standard deviation of a coupon price is 72 percent larger than that of return of a safe asset. Therefore, a return of mortgage backed securities is more volatile than that of return of a safe asset in US. Compared to Japan, price variations of mortgage backed securities is larger on those of return of a safe asset in US.

As the case for Japan, we can assume the same mapping from our model to US data. In this case, banks B are like Fannie Mae, Freddie Mac, and Ginnie Mae.[8] These three

[7]Source: SIFMA and Bloomberg.

[8]Fannie Mae and Freddie Mac issue uniform mortgage-backed security (UMBS) from 2019.

financial institutions have a large share in US mortgage backed security market.[9] Banks C are commercial banks, money market funds, pension funds, mutual funds, and the Federal Reserve. Banks A are a traditional commercial banks and non banks specialized to mortgage loans. We have the same analysis to reduce price variation of mortgage backed securities as in Japan and we need to identify which shocks are dominant in US market.

6.1 Bayesian Estimation for US Mortgage Backed Securities

For US data, I estimate a financial chain model using Bayesian estimation. In estimating the model, I use a log-linearized model as shown in Section 3.

6.1.1 US Data

In estimation, I use monthly data series, over the sample period from May 2005 to December 2021, including an average coupon price, average WAC, and U.S. Treasury Securities at 10-Year.

In a model, an average coupon price, average WAC, and U.S. Treasury Securities at 10-Year correspond to R_t^B, R_t^A, and X_t^A, respectively.

6.1.2 Calibrations and Priors for Estimation

I first calibrate some of the deep parameters. I basically use the same calibration parameters as in Japan's case. A discount rate is a conventional value in a monthly base as $\beta = 0.996$. I set separation rates in two market as $\rho = 0.03$ and $\dot{\rho} = 0.03$. I set scaling parameters such as $Z^A = 1$, $Z^B = 2$, and $Z^C = 8$. Moreover, I calibrate $\rho_{XA} = \rho_{XB} = \rho_{XC} = 0.95$ since auto-correlations of an average coupon price, average WAC, and U.S. Treasury Securities at 10-Year are about 0.99.

As shown in Table 10, I assume Beta distribution for parameters that have restrictions $[0, 1]$ such as b, $\dot{b}$, α, and $\dot{\alpha}$. For inverse Gamma distribution for standard deviations for shocks such as σ_{XA}, σ_{XB}, and σ_{XC}. I assume normal distributions for other parameters.

[9] For example, please see Ginnie Mae (2021).

6.1.3 Estimation Results

Table 11 report estimated posterior means and the 5th and 95th percentiles.

Regarding bargaining power in two markets, a bargaining power of banks A in the first market is $b = 0.506$ and a bargaining power of banks B in the second market is $\dot{b} = 0.4846$. Thus, bargaining powers are the almost same in buyer and seller sides in two markets. For matching elasticity, we have $\alpha = 0.4655$ and $\dot{\alpha} = 0.5222$. Matching elasticities are also not so different in buyer and seller sides in two markets.

There is heterogeneity in US financial markets since a matching efficiency in a first market $\chi = 0.4784$ is much bigger than in a second market $\dot{\chi} = 0.0492$. It implies that selling final product by matches is not so easy in US. This is partially because our data includes a period of financial crisis occured in US. On the other hand, entry costs are similar in two markets as $\kappa = 0.9424$ and $\dot{\kappa} = 1.0735$.

7 How to Design Market Policy and Regulation for Price Stability in Japan and US: Examples

Financial crises in US and Euro around 2010 show the critical roles of financial markets in the U.S. and the Euro area to induce financial disturbances. Only a current policy framework, such as monetary policy, can not fully mitigate nor avoid financial crises and so macroprudential policy is geared toward financial stability.[10]

7.1 Static Analysis for Price Stability in Japan and US

As shown in Section 4, according to parameters for a bargaining power for a price negotiation, price variations sensitively change. In this section, I show how we actually can reduce price variation for mortgage backed securities in Japan and US by changing bargaining power parameters. In particular, we focus on a static analysis in which

[10]Borio (2011) and Drehmann, Borio, and Tsatsaronis (2012) show empirical results to support this point.

parameters are not time-varying and we compare price variations among different constant parameters. Moreover, by a variance decomposition, we know that both a shock through financial intermediation and a shock in a final demand play dominant roles for price variations in Japan and US. We assume these two types of shocks in simulations. It notes that we show some example cases to decrease price variations and we do not seek parameter sets to minimize price variations. Moreover, simulation results do not necessarily match with those in Table 3 and 4 since estimated parameters for Japan and US are different from those in simulations for Table 3 and 4.

A shock in a final investor's demand for mortgage backed security R_t^C holds nontrivial effect on price variations in Japan and US. To a shock of R_t^C, price variations in two markets can decrease when we put a larger bargaining power on intermediation banks, i.e., Japan Housing Finance Agency in Japan and Fannie Mae, Freddie Mac, and Ginnie Mae in US, that demand original loans in a first market and a larger bargaining power on investors that finally demands financial product in a second market as shown in the case of R_t^C with $b = 0.3$ and $\dot{b} = 0.3$ in Table 3. Table 12 shows that price variations decrease in both Japan and US to a shock of R_t^C when we set larger parameters as $b = 0.3$ and $\dot{b} = 0.3$ compared to estimated parameters.

A shock in a second market X_t^B also holds nontrivial effect on price variations in Japan and US. Thus, to reduce price variation in the first market, we need to decrease b and give a larger bargaining power on Japan Housing Finance Agency in Japan and Fannie Mae, Freddie Mac, and Ginnie Mae in US. At the same time, price variations in the first market can further decrease by giving a bigger bargaining power on Japan Housing Finance Agency, Fannie Mae, Freddie Mac, and Ginnie Mae in the second market as shown in the case of X_t^B with $b = 0.3$ and $\dot{b} = 0.7$ in Table 3. Table 12 shows that price variations decrease in both Japan and US to a shock of X_t^B when we change estimated parameters to $b = 0.3$ and $\dot{b} = 0.7$. Here, $b = 0.3$ is smaller than estimated parameters and $\dot{b} = 0.7$ is larger than estimated parameters.

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Table 1: Parameter Calibration

Parameters	Explanations	Values
β	Discount factor	0.996
ρ	Exit rate in the first market	0.1
$\dot{\rho}$	Exit rate in the second market	0.1
α	Matching elasticity in the first market	0.5
$\dot{\alpha}$	Matching elasticity in the second market	0.5
b	Banks A's bargaining power in the first market	0.5
$\dot{b}$	Banks B's bargaining power in the second market	0.5
χ	Matching efficiency in the first market	0.5
$\dot{\chi}$	Matching efficiency in the second market	0.5
κ	Entry cost into the first market	2
$\dot{\kappa}$	Entry cost into the second market	2
ρ_{XA}	Shock persistence for banks A	0.5
ρ_{XB}	Shock persistence for banks B	0.5
ρ_{ZC}	Shock persistence for banks C	0.5
Z^A	Banks B's borrowing from banks A	1
Z^B	Banks C's borrowing from banks B	2
Z^C	Banks C's lending	8

Table 2: Simulation Results for Separation Rates

X_t^A shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\rho = \dot{\rho} = 0.1$	0.072279	0.023046	0.400526	0.312646
$\rho = \dot{\rho} = 0.05$	0.053575	0.018254	0.363826	0.315883
$\rho = \dot{\rho} = 0.15$	0.084596	0.026520	0.456164	0.334710
X_t^B shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\rho = \dot{\rho} = 0.1$	0.034434	0.074143	0.874885	1.005834
$\rho = \dot{\rho} = 0.05$	0.006408	0.059948	0.912704	1.037386
$\rho = \dot{\rho} = 0.15$	0.057442	0.083395	0.914833	1.052537
R_t^C shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\rho = \dot{\rho} = 0.1$	1.006554	1.025198	3.204207	2.501171
$\rho = \dot{\rho} = 0.05$	1.030230	1.032912	2.910606	2.527067
$\rho = \dot{\rho} = 0.15$	0.991878	1.022406	3.649309	2.677681

Note: Std denotes a standard deviation.

Table 3: Simulation Results for Bargaining Powers

X_t^A shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$b = \dot{b} = 0.5$	0.072279	0.023046	0.400526	0.312646
$b = 0.3$ and $\dot{b} = 0.3$	0.083557	0.037458	0.375713	0.303726
$b = 0.7$ and $\dot{b} = 0.7$	0.050497	0.010964	0.471004	0.371867
$b = 0.3$ and $\dot{b} = 0.7$	0.088614	0.015074	0.353257	0.255326
$b = 0.7$ and $\dot{b} = 0.3$	0.063101	0.032911	0.547619	0.474742
X_t^B shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$b = \dot{b} = 0.5$	0.034434	0.074143	0.874885	1.005834
$b = 0.3$ and $\dot{b} = 0.3$	0.031884	0.105827	0.635144	0.858085
$b = 0.7$ and $\dot{b} = 0.7$	0.038915	0.048077	1.574857	1.63062
$b = 0.3$ and $\dot{b} = 0.7$	0.010845	0.038604	0.588239	0.653897
$b = 0.7$ and $\dot{b} = 0.3$	0.106136	0.150328	1.933207	2.168472
R_t^C shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$b = \dot{b} = 0.5$	1.006554	1.025198	3.204207	2.501171
$b = 0.3$ and $\dot{b} = 0.3$	0.964991	0.947003	3.005701	2.429807
$b = 0.7$ and $\dot{b} = 0.7$	1.056106	1.088776	3.768029	2.974936
$b = 0.3$ and $\dot{b} = 0.7$	1.019867	1.078002	2.826053	2.042608
$b = 0.7$ and $\dot{b} = 0.3$	0.951916	0.942995	4.380951	3.797932

Note: Std denotes a standard deviation.

Table 4: Simulation Results for Matching Elasticity

X_t^A shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\alpha = \dot{\alpha} = 0.5$	0.072279	0.023046	0.400526	0.312646
$\alpha = 0.3$ and $\dot{\alpha} = 0.3$	0.079054	0.022731	0.973413	0.357426
$\alpha = 0.7$ and $\dot{\alpha} = 0.7$	0.069805	0.023552	0.227940	0.363534
$\alpha = 0.3$ and $\dot{\alpha} = 0.7$	0.066378	0.021476	0.412601	0.271238
$\alpha = 0.7$ and $\dot{\alpha} = 0.3$	0.074892	0.023193	0.463835	0.401104
X_t^B shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\alpha = \dot{\alpha} = 0.5$	0.034434	0.074143	0.874885	1.005834
$\alpha = 0.3$ and $\dot{\alpha} = 0.3$	0.034400	0.070679	2.411268	1.111365
$\alpha = 0.7$ and $\dot{\alpha} = 0.7$	0.042691	0.077476	0.414220	1.195877
$\alpha = 0.3$ and $\dot{\alpha} = 0.7$	0.035028	0.073991	0.711827	0.934492
$\alpha = 0.7$ and $\dot{\alpha} = 0.3$	0.030629	0.072424	1.159625	1.252525
R_t^C shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\alpha = \dot{\alpha} = 0.5$	1.006554	1.025198	3.204207	2.501171
$\alpha = 0.3$ and $\dot{\alpha} = 0.3$	1.058822	1.051859	7.787304	2.859406
$\alpha = 0.7$ and $\dot{\alpha} = 0.7$	0.937063	1.000632	1.823518	2.908271
$\alpha = 0.3$ and $\dot{\alpha} = 0.7$	1.018281	1.024926	3.300805	2.169905
$\alpha = 0.7$ and $\dot{\alpha} = 0.3$	1.026759	1.040968	3.710679	3.208833

Note: Std denotes a standard deviation.

Table 5: Simulation Results for Entry Cost

X_t^A shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\kappa = \dot{\kappa} = 2$	0.072279	0.023046	0.400526	0.312646
$\kappa = \dot{\kappa} = 1$	0.047279	0.015522	0.446549	0.370950
$\kappa = \dot{\kappa} = 3$	0.085719	0.027199	0.375524	0.284594
$\kappa = 1$ and $\dot{\kappa} = 3$	0.073280	0.024515	0.385283	0.297317
$\kappa = 3$ and $\dot{\kappa} = 1$	0.061221	0.018497	0.4353	0.351109
X_t^B shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\kappa = \dot{\kappa} = 2$	0.034434	0.074143	0.874885	1.005834
$\kappa = \dot{\kappa} = 1$	0.018995	0.054113	1.060928	1.293169
$\kappa = \dot{\kappa} = 3$	0.060138	0.084688	0.785710	0.886107
$\kappa = 1$ and $\dot{\kappa} = 3$	0.038742	0.079283	0.823866	0.961557
$\kappa = 3$ and $\dot{\kappa} = 1$	0.009266	0.060862	0.999709	1.155276
R_t^C shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
$\kappa = \dot{\kappa} = 2$	1.006554	1.025198	3.204207	2.501171
$\kappa = \dot{\kappa} = 1$	1.092278	1.061553	3.572391	2.967602
$\kappa = \dot{\kappa} = 3$	0.968279	1.008316	3.004191	2.276753
$\kappa = 1$ and $\dot{\kappa} = 3$	0.999792	1.019983	3.08226	2.378534
$\kappa = 3$ and $\dot{\kappa} = 1$	1.047623	1.045862	3.482398	2.808874

Note: Std denotes a standard deviation.

Table 6: Basic Statistics for Japanese Data

	Standard Deviation	Average	Max	Min
10-years JGB	0.59	0.6	1.89	-0.26
Average WAC	0.68	1.53	3.04	0.69
Coupon Price	0.69	1.07	2.34	0.15

Data: Bloomberg and Japan Housing Finance Agency.

Note: Monthly base.

Table 7: Prior Distributions for Japan Data

Parameters	Explanations	Means	S.D	Distribution
α	Matching elasticity in first market	0.5	0.15	Beta
$\dot{\alpha}$	Matching elasticity in second market	0.5	0.15	Beta
b	Banks A's bargaining power in first market	0.5	0.05	Beta
$\dot{b}$	Banks B's bargaining power in second market	0.5	0.05	Beta
κ	Entry cost into the first market	1	0.15	Normal
$\dot{\kappa}$	Entry cost into the second market	1	0.15	Normal
χ	Matching efficiency in the first market	0.5	0.15	Normal
$\dot{\chi}$	Matching efficiency in the second market	0.5	0.15	Normal
ρ_{XA}	Shock persistence for banks A	0.5	0.1	Beta
ρ_{XB}	Shock persistence for banks B	0.5	0.1	Beta
ρ_{XC}	Shock persistence for banks C	0.5	0.1	Beta
σ_{XA}	Standard deviation of shock banks A	0.2	0.1	inv(Gamma)
σ_{XB}	Standard deviation of shock banks B	0.2	0.1	inv(Gamma)
σ_{XC}	Standard deviation of shock banks C	0.2	0.1	inv(Gamma)

Table 8: Estimated Means and Posterior Distributions for Japan Data

Parameters	Posterior Means	5th and 95th percentiles
α	0.5545	[0.4819, 0.6354]
$\dot{\alpha}$	0.6756	[0.613, 0.7319]
b	0.4764	[0.433, 0.5121]
$\dot{b}$	0.4812	[0.4459, 0.516]
κ	1.6665	[1.4796, 1.8805]
$\dot{\kappa}$	2.2376	[2.0302, 2.4801]
χ	0.5997	[0.3939, 0.8258]
$\dot{\chi}$	0.3143	[0.2544, 0.37]
ρ_{XA}	0.7871	[0.7833, 0.7902]
ρ_{XB}	0.7830	[0.7743, 0.7902]
ρ_{ZC}	0.5872	[0.7832, 0.7902]
σ_{XA}	0.2342	[2.3516, 2.8929]
σ_{XB}	4.1751	[0.091, 0.2904]
σ_{XC}	0.3077	[0.7105, 0.8385]

Table 9: Basic Statistics for US Data

	Standard Deviation	Average	Max	Min
U.S. Treasury Securities 10-Year	0.99	0.72	2.89	-1.07
Average WAC	1.18	6.16	8.86	4.66
Average Coupon	1.7	1.72	5.69	0.38

Data: Bloomberg and Federal Reserve Economic Data.

Note: Monthly base.

Table 10: Prior Distributions for US Data

parameters	Explanations	Means	S.D	Distribution
α	Matching elasticity in first market	0.5	0.1	Beta
$\dot{\alpha}$	Matching elasticity in second market	0.5	0.1	Beta
b	Banks A's bargaining power in first market	0.5	0.05	Beta
$\dot{b}$	Banks B's bargaining power in second market	0.5	0.05	Beta
κ	Entry cost into the first market	1	0.2	Normal
$\dot{\kappa}$	Entry cost into the second market	1	0.2	Normal
χ	Matching efficiency in the first market	0.5	0.2	Normal
$\dot{\chi}$	Matching efficiency in the second market	0.5	0.2	Normal
σ_{XA}	Standard deviation of shock banks A	0.15	0.1	inv(Gamma)
σ_{XB}	Standard deviation of shock banks B	0.15	0.1	inv(Gamma)
σ_{XC}	Standard deviation of shock banks C	0.15	0.1	inv(Gamma)

Table 11: Estimated Means and Posterior Distributions for US Data

Parameters	Posterior Means	5th and 95th percentiles
α	0.4655	[0.3396, 0.5895]
$\dot{\alpha}$	0.5222	[0.3858, 0.6594]
b	0.506	[0.4301, 0.5866]
$\dot{b}$	0.4846	[0.4119, 0.5481]
κ	0.9424	[0.6323, 1.2725]
$\dot{\kappa}$	1.0735	[0.8079, 1.3765]
χ	0.4784	[0.27, 0.6875]
$\dot{\chi}$	0.0492	[0.0166, 0.0841]
σ_{XA}	0.1758	[0.1548, 0.1984]
σ_{XB}	7.0885	[5.9449, 8.3575]
σ_{XC}	0.2728	[0.2399, 0.3018]

Table 12: Static Analyses for Japan and US

X_t^B shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
Japan	0.009647	0.076735	0.346540	1.040909
$b = 0.3$ and $\dot{b} = 0.7$ for Japan	0.004446	0.038154	0.171231	0.517554
US	0.029096	0.155473	1.481980	1.800123
$b = 0.3$ and $\dot{b} = 0.7$ for US	0.014469	0.086379	0.826161	1.000126
R_t^C shock	Std(R_t^A)	Std(R_t^B)	Std(θ)	Std($\dot{\theta}$)
Japan	1.048458	1.086254	1.417245	1.488346
$b = 0.3$ and $\dot{b} = 0.3$ for Japan	0.892110	0.926538	2.091193	2.7709
US	2.869635	2.789253	5.138514	4.049632
$b = 0.3$ and $\dot{b} = 0.3$ for US	2.616369	2.503168	8.370174	7.362023

Note: Std denotes a standard deviation.

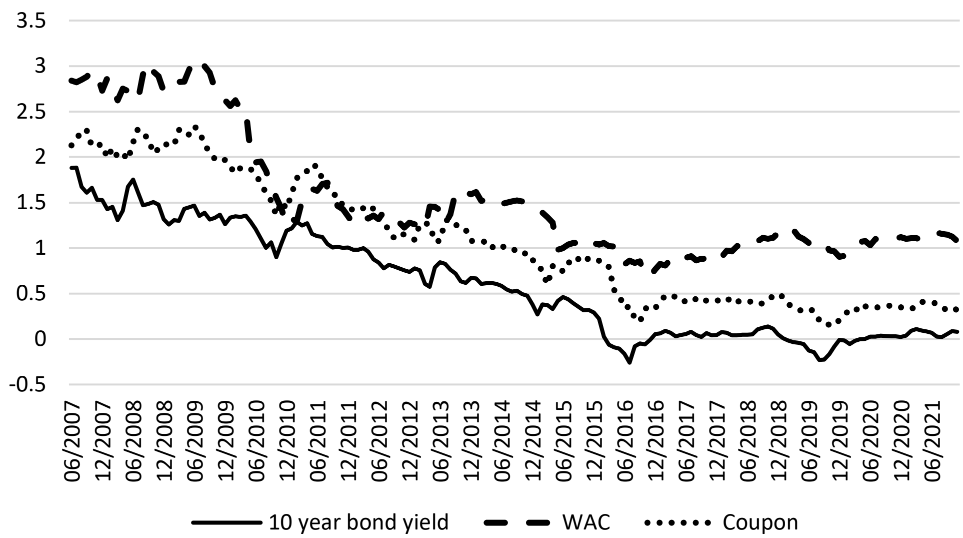

Figure 1: Coupons, WAC, and 10-years JGB in Japan

Data: Bloomberg and Japan Housing Finance Agency.

Note: Monthly base.

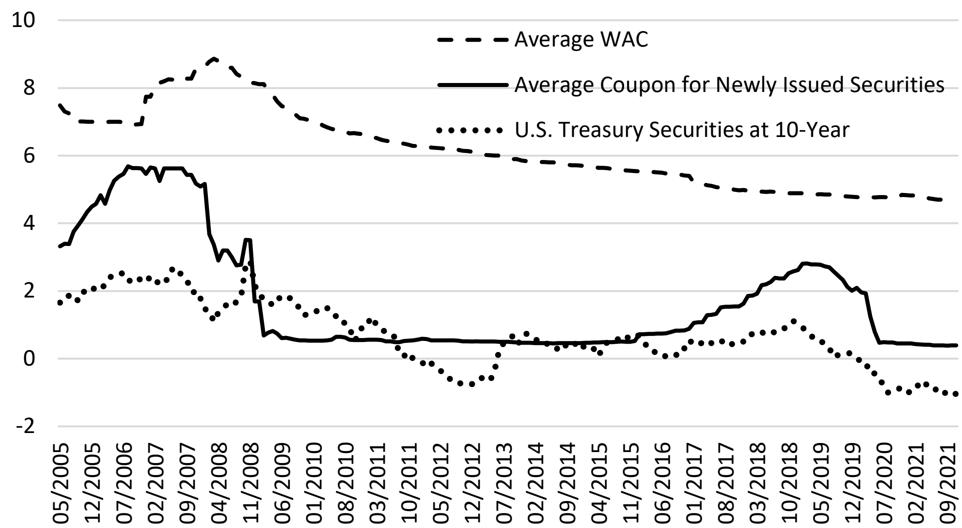

Figure 2: Coupons, WAC, and U.S. Treasury Securities 10-Year in US

Data: Bloomberg and Federal Reserve Economic Data.

Note: Monthly base.